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POWER PLUGS AND FLEXIBLE CORDS

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		Page
1.	INTRODUCTION	1
2.	APPLIANCES	2
3.	FLEXIBLE CORDS	2
4.	POWER PLUGS	3
5.	EXTENSION CORDS	5
6.	SAFETY	7
7.	TEST QUESTIONS	8

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1. INTRODUCTION.

1.1 Don't ever be careless when handling electrical power - particularly 240 volt a.c. commercial power. A small tingle off the frame of an appliance will certainly make you aware that something is wrong, but if that small tingle exceeds 10 mA you may not be able to let go. At about 100 mA, after a period of one second, you could be dead. Once above 1 Amp you may survive with internal injuries after the burns have created an insulating effect. Of course body contact resistance and the current path through the body make every situation quite individual, but you seldom get a second chance.

1.2 Since electrical rules and regulations can vary from State to State, this paper uses Standards Association of Australia publications as reference. Nevertheless you should be fully aware of the limitations imposed by your State Electrical Authority, and the Department, as regards wiring to plugs and appliances.

E.T.S. 12/0005

2. APPLIANCES.

2.1 In the interests of safety, no appliances should have any live parts accessible to the user. This can be assured by either Earthing or Double Insulating the appliances.

2.2 EARTHED APPLIANCES. The protective screen or case may be made of insulating material or metal provided it is insulated from current carrying parts. If the protective case is of metal, a failure of the insulation or an accident, like the escape of a strand of flexible cord from under a clamping screw, may bridge the gap to the case and raise the potential of the case to full mains voltage above earth. This would provide an extremely dangerous condition which could prove fatal. It is therefore required that any metal that can be touched shall be 'earthed'. So long as this condition is maintained there can be no danger in touching the metal, for even in the event of failure of insulation, no appreciable potential can exist between it and the person who is also making contact with earth.

If earthing is to be relied upon for protection it is essential that only cords, plugs and sockets which incorporate an earth are used.

2.3 DOUBLE INSULATED APPLIANCES. An alternative to protection by earthing exposed metal is the principle of 'all insulation'. In this form of construction an appliance is totally enclosed in a casing made of insulating material, having no external metal. However not many appliances can be built this way, for structural reasons, so a form of construction known as Double Insulation has been devised. This permits the use of external metal without the necessity of earthing.

As its name implies, double insulation involves the provision of two completely separate sets of insulation between the current-carrying parts and any metal accessible to the user. If either set of insulation breaks down or accidentally becomes short-circuited by strands of flex it will not result in risk to the user who is protected by a second set of insulation. For the accessible metal to become live, both sets of insulation must break down, which is extremely unlikely.

Since the absence of an earthing terminal on an appliance having external metal may confuse a user not familiar with the principles of Double Insulation, such appliances are clearly marked -

DO NOT EARTH – DOUBLE INSULATED

Consequently, only a two core flexible cord is used for these appliances.

2.4 TESTING. All appliances should be tested at regular intervals. The frequency of the tests depends on the type of appliance and the use to which it is subjected. Engineering Instructions provide the relevant details of these tests.

3. FLEXIBLE CORDS.

3.1 Most appliances are fitted with flexible cords about 6 feet long which terminate in a plug. The flexible cord may consist of either two or three conductors depending upon whether it is to be used on double or single insulated appliances. The conductors provide connection for Earth, Active and Neutral and are colour coded for ease of identification. The following are SAA definitions -

- EARTH - Green, or Green and Yellow. This conductor connects to all portions of the appliance required to be earthed.

- ACTIVE - Red. The Active conductor is maintained at a difference of potential from the neutral or earthed conductor.
- NEUTRAL - Black. This is the conductor of a three wire system which is maintained at an intermediate and approximately uniform potential in respect to the active conductor, and close to or at earth potential.

An international colour code has been adopted by several countries, including the United Kingdom, which is -

- Earth - Green and Yellow.
- Active - Brown.
- Neutral - Blue.

At this stage, the SAA approved colours are the standard to be used in Australia.

3.2 Flexible cords with the insulated cores covered by a rubber or P.V.C. sheath are considered to provide double insulation between the core conductors and any metal in contact with the cord.

Cords come in five different categories. The choice of cord depends largely upon the type of appliance, the current rating of the appliance, and the environment in which it is used. SAA publication C100 lists the cords allowable for each type of appliance.

4. POWER PLUGS.

4.1 The most common power plug is a three pin plug used with 240 volt a.c. appliances. These plugs are made of different materials with different cord entries, cord anchorages, and terminal arrangements, but all conform to the same general standard. Below are typical plugs showing safe terminals, firm anchorage and identification. The most common plug rating is 10 Amps. 15 Amp plugs and outlets have a wider earthpin and slot so that it is not possible to plug a 15 Amp plug into a 10 Amp outlet. Always ensure that the plug is correctly rated for the appliance.

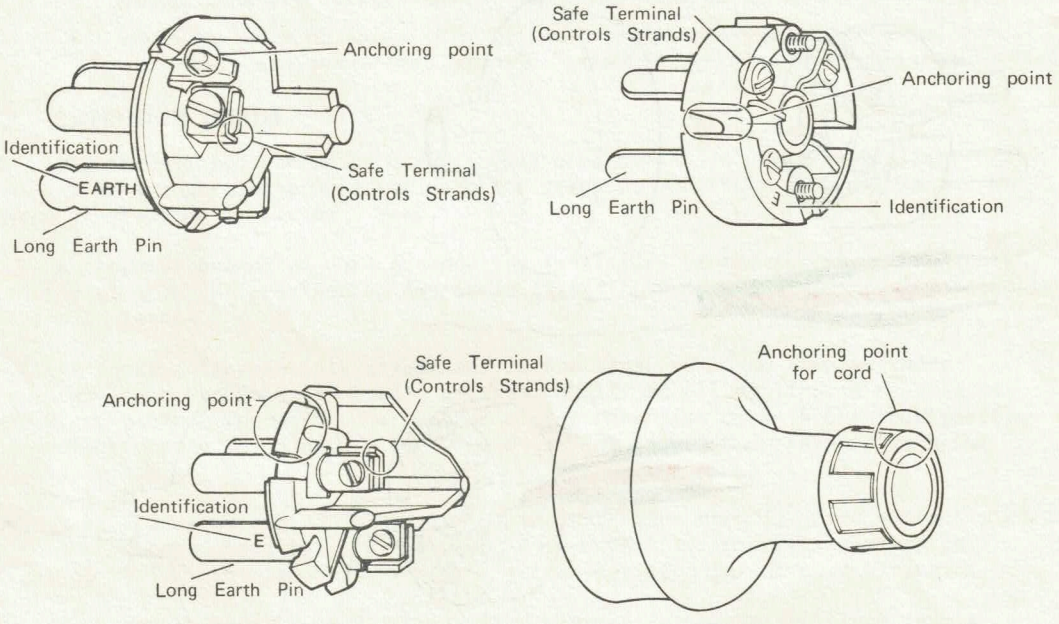


FIG. 1. COMMON FEATURES OF TYPICAL PLUGS.

4.2 PLUG TERMINATION.

- The outer sheath should be removed so that there is just enough of each insulated conductor to go around the separate paths in the plug. Care must be taken to ensure that the insulation on the conductors is not nicked during the removal of the sheath. (Fig. 2a).

- The removal of the insulation from the conductors should leave just sufficient of the copper wires bared to be effectively terminated. The earth lead should be cut so that it will be slack when terminated. This allows any strain that may occur to be taken on the active or neutral. Care must be taken to ensure that the fine wires are not nicked during the removal of the insulation. (Fig. 2a).

- The wires of each conductor should be twisted firmly before being terminated. (Fig. 2c).

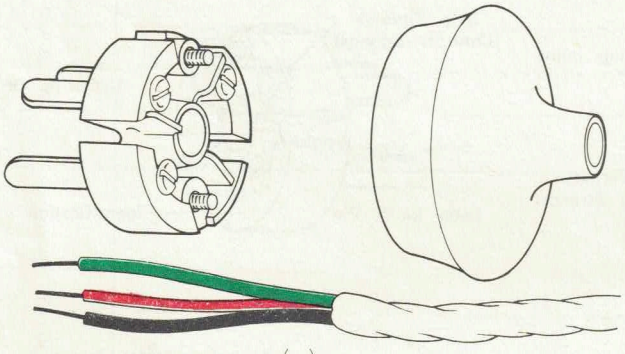
NOTE: Wires should not be soldered because solder will "cold flow" under pressure and the terminal will soon loosen. If termination is under a screw head rather than a clamp, the conductor should feed under the screw in a clockwise direction.

- All conductors pass through the plug cover and should follow their separate paths to their terminals. (Fig. 2b).

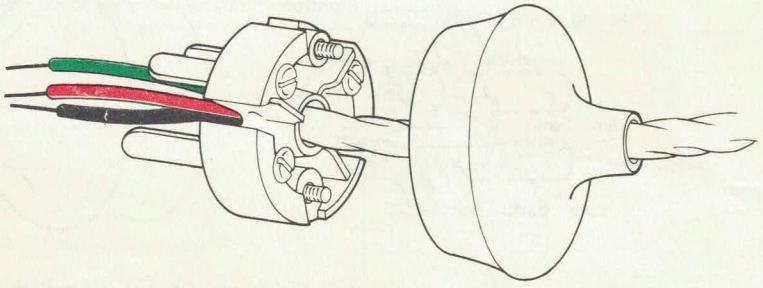
- Each conductor when terminated should have its insulation right up to the terminal.

- The Earth conductor (Green or Green and Yellow) should terminate on the longest pin, which is always marked with an E or Earth, and often plated a different colour. If the other two terminals are marked, the Active conductor (Red) should go on the "A" terminal, the Neutral conductor (Black) should go on the "N" terminal. (Fig. 2d).

In the case of unmarked plugs, the terminal face (rear) of the plug is identical in layout to the face of a socket, so that the terminals should be E, A and N in a clockwise direction.



(a)



(b)

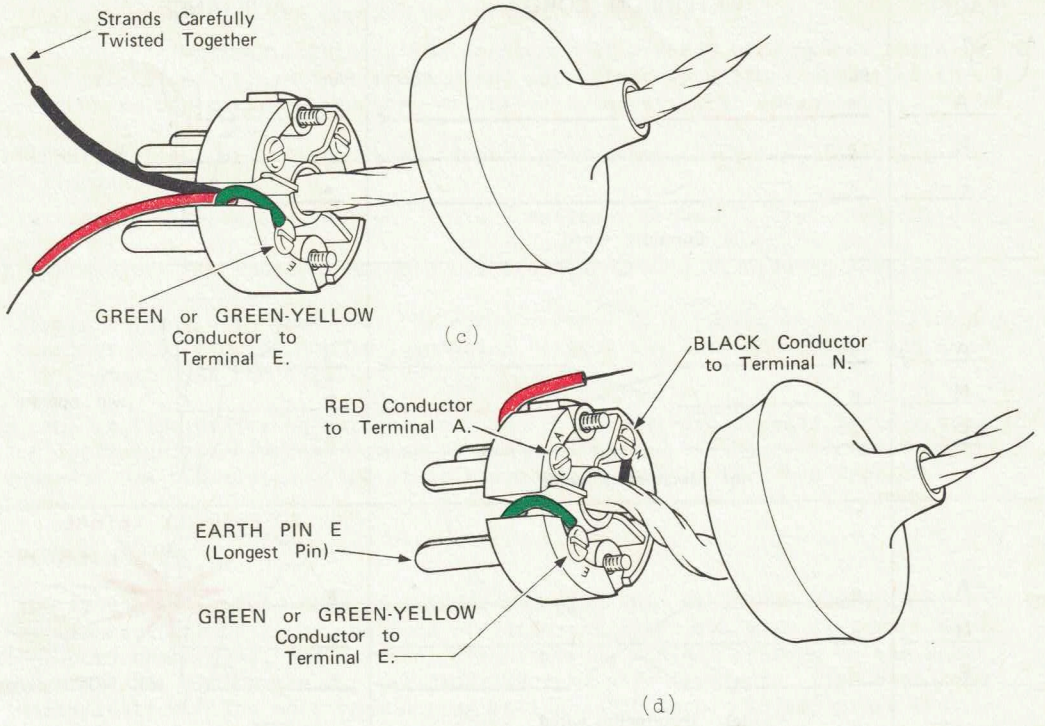

Strands Carefully Twisted Together
GREEN or GREEN-YELLOW Conductor to Terminal E.
(c)
BLACK Conductor to Terminal N.
RED Conductor to Terminal A.
EARTH PIN E (Longest Pin)
GREEN or GREEN-YELLOW Conductor to Terminal E.
(d)

FIG. 2. TYPICAL PLUG TERMINATION.

- Before a plug is closed, all terminals should be checked to ensure that connections are correct and screws firm, with no stray strands of wire.
- After any work on cords or plugs, all conductors should be tested for continuity and insulation between conductors, before the appliance is used.

5. EXTENSION CORDS.

5.1 The three-cored extension cord is something almost uniquely Australian. It is a convenience which we take for granted, but it is responsible for the death of about 20 people each year.

5.2 A properly assembled cord extends the facilities of the socket into which it is plugged and provides no danger in itself, but if it is incorrectly assembled it can be lethal.

5.3 Of course, "incorrectly assembled" in the sense of loose strands under terminals or unclamped leads, applies equally to all appliances as well as extension cords. The particular danger of the extension cord is the transposition of connections to the pins, so that the mains end does not correspond with the appliance end.

5.4 Take a look at Fig. 3. The plug of the extension cord is wired correctly as is the mains socket, but the extension cord socket is incorrectly wired in Figs. 3b to f. That is, there has been a transposition in the cord wiring.

Consider what happens in each case as the unsuspecting tradesman plugs in his correctly wired, and from past experience, perfectly safe, appliance.

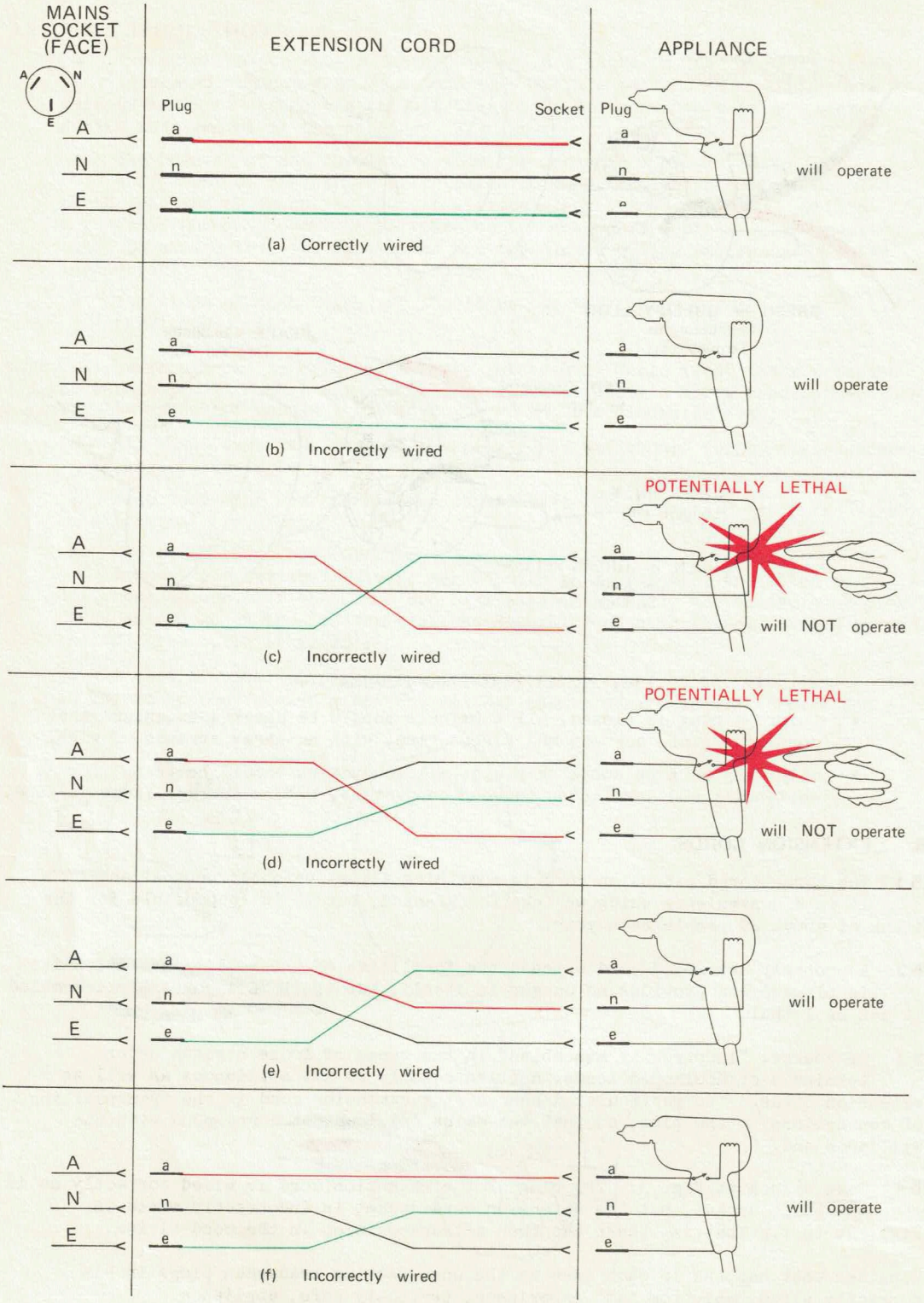


FIG. 3. EXTENSION CORD WIRING CONFIGURATIONS. (Standard Socket Wiring).

5.5 In Figs. 3a, b, e and f the appliance will work, but in the two cases c and d where it does not, the frame is live and provides a potentially lethal situation.

5.6 Let us assume that the tradesman, having used the drill with no mishaps in one situation, now shifts the extension cord to another power point which is not wired as recommended, but has the Active and Neutral transposed. If the extension cord used is wired as in Fig. 4a or b, which equates to the cords in Figs. 3e and f, the tradesman is in for a shock, maybe a fatal one.

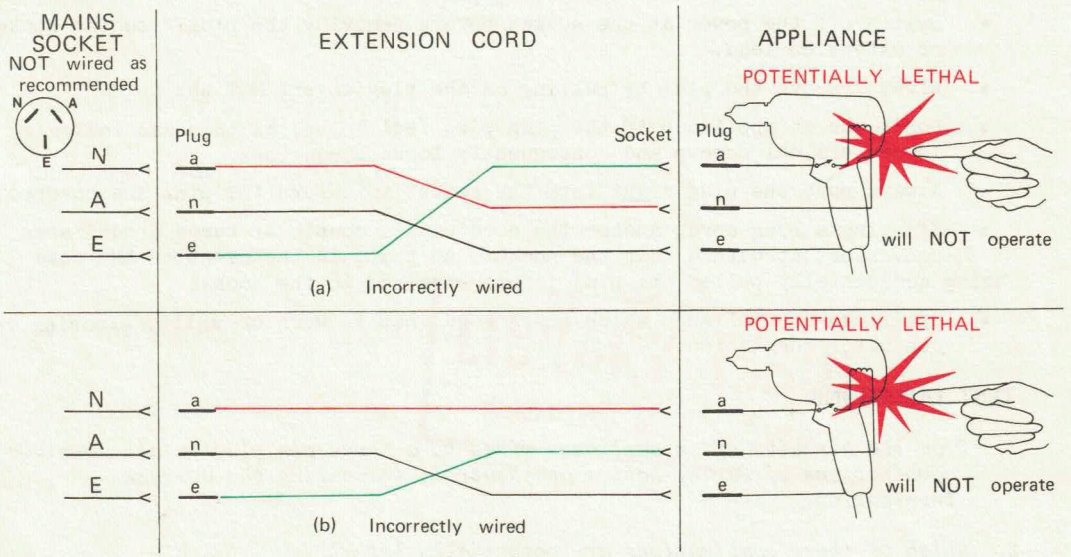


FIG. 4. EXTENSION CORD WIRING CONFIGURATIONS (Unstandard socket wiring)

5.7 When using an extension cord which is normally stored on a drum or spool, do not leave the unused portion coiled on the spool as it tends to heat up, softening the P.V.C. (causing it to flow) so that conductors may short together.

5.8 Never use an extension cord for an appliance which has a higher current rating than the cord.

6. SAFETY.

- If you are using an extension cord or appliance and it does not work after being switched on:

  - DO NOT TOUCH THE APPLIANCE FURTHER
  - SWITCH OFF AT THE SOCKET
  - REMOVE THE PLUG

  Only then is it safe to touch the appliance. Have the appliance (and extension cord) checked.

- Do not make or repair cords and plugs unless authorised to do so.
- After work has been carried out on plug or cord terminations, ensure that the cord is tested for continuity, transpositions, and insulation before using.

- Many appliances incorporate a double pole switch which breaks both active and neutral conductors, but appliances which have only a single pole switch should have the switch in the Active conductor. As this is dependent on the correct wiring of the plug and socket it cannot be assumed to be so. It is necessary therefore, for the plug to be removed from the mains socket before the appliance can be considered safe to work on, rather than relying on the switch.

- Although Departmental policy generally does not favour two-way adaptors, you will come across them. Do not use mirror image two-way adaptors, that is, adaptors manufactured with the sockets set back to back so that one socket is wired correctly as in Fig. 3 and one is wired incorrectly as in Fig. 4. The Active on each socket is wired to the Neutral on the other.

- Switch off the power at the socket before removing the plug from the socket or extension lead.

- Always remove the plug by pulling on the plug cover, NOT the cord.

- Don't use an appliance if the plug pins feel loose, as this can indicate loose terminal screws and consequently loose conductors.

- Always push the plug right into the socket to ensure the pins are covered.

- If using a long cord, anchor the cord with a couple of turns around some convenient structure near the socket, so that, in the event of the cord being accidentally pulled the plug is not strained in the socket.

- Don't use an appliance which has a cord that is worn or split, exposing the conductor insulation.

7. TEST QUESTIONS.

1. *Draw the circuits of an appliance wired to a three pin plug in all possible combinations of Earth, Active and Neutral, indicating the correct termination.*

2. *Which of these combinations are potentially lethal?*

3. *If the socket was not wired as recommended, but had Active and Neutral transposed, what effect would that have on your above circuits and the answer to question 2?*

4. *What relationship does question 3 have to the safety rule about mirror image two-way adaptors?*

5. *What is the colour coding for a three core cord?*

END.